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ABSTRACT

This experiment examined two processes which might account for developmental increases in accuracy in visual recognition tasks: age-related increases in efficiency of scanning during inspection, and age-related increases in the ability to make decisions systematically during test. Critical details necessary for recognition were highlighted as inspection, test, both or neither. Four groups were tested at each of three ages, 4, 6, and 8 years. Highlighting at inspection was found to increase accuracy and decrease response time for all age groups. Highlighting at test improved accuracy only when highlighting had also occurred at inspection. Highlighting at test also decreased response time at all ages, but the effect was larger for older groups. Age differences in accuracy were significant in all four conditions. Changes in scanning and decision processes do not seem to be powerful factors accounting for improvement in visual recognition in the 4 to 8 year age range. (Author/RH)

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Development of Encoding and Decision Processes in Visual Recognition

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Running head: Encoding and Decision Processes

Abstract

This experiment examined two processes which might account for developmental increases in accuracy in visual recognition tasks: age-related increases in efficiency of scanning during inspection, and age-related increases in the ability to make decisions systematically during test. Critical details necessary for recognition were highlighted at inspection, test, both or neither. Four groups were tested at each of three ages, 4, 6 and 8 years. Highlighting at inspection was found to increase accuracy and decrease response time for all age groups. Highlighting at test improved accuracy only when highlighting had also occurred at inspection. Highlighting at test also decreased response time at all ages, but the effect was larger for older groups. Age differences in accuracy were however significant in all four conditions. Changes in scanning and decision processes do not seem to be powerful factors accounting for improvement in visual recognition in the 4 to 8 year age range.

Development of Encoding and Decision Processes in Visual Recognition

Recent interest in the field of memory development in children has begun to focus on the underlying cognitive processes involved (Brown & DeLoache, 1978). Mnemonic abilities generally increase with age; the important question to answer is: Why? One task of interest is that of visual recognition. Claims that recognition memory for pictures is a "passive" process, fully developed in very young children (e.g., Brown, 1975; Nelson, 1971) are not warranted; visual recognition memory clearly does improve with age (e.g., Nelson & Kosslyn, 1976; Newcombe, Rogoff & Kagan, 1977; Tversky & Teiffer, 1976). Research has also shown that the task is not a passive one: performance is improved when subjects are informed that they will be asked to recognize rather than recall stimuli (Tversky, 1973), when they are asked to label the stimuli (Nelson & Kosslyn, 1976), and when they are given specific payoffs for recognizing certain stimuli correctly (Loftus, 1972).

However, as Brown and DeLoache point out, it is not surprising and not in itself informative to find that the visual recognition task can show developmental differences. The question of interest is what processes show developmental change. Which of the component processes of the recognition task are young children unable to perform efficiently? Fajnsztejn-Pollack (1973) and Wagner (1978) have shown convincingly that the rate of decay of stored pictorial information does not change with age. Thus, the encoding (or inspection) phase and the test (or decision) phase of the task must involve some processes which change developmentally.

Studies of encoding of visual stimuli for later recognition have not identified any very powerful factors which seem to differentiate people of different ages. Three studies have examined the effect of requiring labeling or verbal description during inspection of a picture. Nelson and Kosslyn (1976) found that while labeling improved recognition memory, it did so equally for five year-olds and for adults. Stein and Feldman (1977) found that recognition accuracy for object detail in pictures was improved for third-graders and adults when the experimenter prompted complete verbal descriptions during inspection or when the subject was asked to tell another person about all details of the picture. Spontaneous (undirected) verbal description did not improve accuracy, and none of the three conditions led to improved accuracy for first graders. Meyer (1978) found that spontaneous verbalization increased recognition accuracy in a standard recognition task, equally over the age range of 4 to 9 years. Verbalization increased false alarms to same-name stimuli, for the youngest children only.

These studies do not converge on conclusions regarding why recognition accuracy improves with age. Stein and Feldman suggested that such trends occur only when strategies are made available to subjects which only older children and adults can use effectively. But this does not explain the fact that developmental increases in accuracy are often found (although not in their study) when such strategies are not made available, for instance in the Nelson and Kosslyn study of labeling. It is also somewhat surprising that adults would be production-deficient on a fairly simple detail recognition

task requiring a seemingly simple strategy of careful attention to detail.

One of the reasons for an interest in the effects of labeling or description is the assumption that young children often do poorly on recognition tasks because they fail to realize the importance of exhaustive inspection of the stimuli and of concern with noticing detail. However, labeling and verbal description do not increase the exhaustiveness of the inspection in any direct way. A more direct test of an exhaustive-inspection hypothesis is provided by Tversky and Teiffer (1976). Tversky and Teiffer gave instructions to pay careful attention to details of objects in order to be able to distinguish them later from similar objects. These instructions did not improve recognition for five- or eight-year olds, but a small effect was observed for twelve-year-olds. An interaction of this type would seem to argue against the idea that young children have problems with exhaustive inspection. However, Tversky and Teiffer's instructional condition may not have been completely understood or obeyed by their younger children. It involved only two examples, and the strategy of careful attention to details then had to be maintained over presentation of 30 line drawings.

In the present experiment, an attempt was made to reduce or eliminate the need to scan widely and absorb a great deal of information in the encoding phase by outlining the detail critical for later recognition in red, and instructing the children that they should concentrate on remembering the part of the picture outlined in red.

This condition is similar to one shown by Howard and Goldin (1979) to increase the ability of kindergarten children to selectively allocate visual attention. If encoding difficulties are an important reason for young children performing less well on recognition tasks than adults, the difference between age groups should be reduced or eliminated in this condition.

A similar procedure was used to investigate the phase of decision processes. When recognition is tested using a forced-choice procedure, and the subject must identify which of two highly similar drawings has been seen before, it is essential for accuracy that the child first compare the alternatives and identify how they differ. There is a large body of evidence available (Day and Bissell, 1978; Vurpillot, 1976) indicating that children, especially preschoolers, may not carry this out, at least not routinely or efficiently. This possibility was evaluated by looking at the effects of pointing out the critical difference between the test items, again with red outlines. If failure to identify the difference between the test items plays an important role in causing recognition errors, these errors should be reduced by the outline procedure.

Four experimental groups were tested at each age. One received the highlighting procedure at both inspection and the later test, another received highlights only at inspection, another only at test, and finally, a fourth group was given a standard recognition task with no highlighting of the critical features in either phase. Response time was recorded as well as recognition accuracy.

Method

Subjects

One hundred and eighty-four subjects were studied. Seventy-two were enrolled in private nursery schools (mean age = 4.0, range 3.3 to 4.5); seventy-two were in public school kindergartens (mean age = 5.7, range 5.0 to 6.8); and forty were in public school third grade classes (mean age = 8.4, range 7.8 to 9.5). Approximately equal numbers of males and females were tested in each age group.

Stimuli

Stimuli were 21 by 28 cm black and white line drawings covered by clear plastic. There were twelve picture pairs showing scenes which seemed likely to be familiar to children, such as a livingroom or a playground. In each scene there were approximately eight different objects. The picture pairs were identical except for one object in the picture, the target item. For instance, for the picture pair showing the playground scene in one picture the target item was a shovel and in the other member of the pair it was a bucket. Placement of the two items was the same in each picture and items were approximately the same size.

There were two different sets of the twelve picture pairs. In one set target items were highlighted by being drawn in red ink. In the other set target items were not highlighted.

The task was a recognition task in which each subject saw twelve different pictures, one from each pair (inspection). Following this each subject saw the twelve pairs of pictures and was asked to choose

the picture previously seen (test). One-fourth of the subjects at each age saw no highlighted items at neither inspection or test, one-fourth of the subjects saw the target item highlighted at inspection but not at test, one-fourth of the subjects saw the target items highlighted at test but not at inspection and one-fourth saw the target items highlighted at both inspection and test.

Design

Three between subject variables were investigated. These were age (three levels), inspection condition (highlighting or no highlighting) and test condition (highlighting or no highlighting).

There were two different random orders of inspection and test. Within each order inspection and test pictures were shown in different orders from each other. Additionally, one-half of the subjects in each order in each condition saw one set of target items at inspection, while the other half saw the other possible set of target items (e.g., one group saw the shovel on inspection of the playground scene and the other group saw the bucket). Position of the correct choice was randomized. Sex of subject was balanced within condition, order and target item inspected.

Procedure

Each subject was told the task involved memory for pictures and the task was demonstrated with two examples. Each example item consisted of showing a picture to the subject and immediately following this presentation showing two pictures. As in the experiment one picture was exactly the same as the first picture shown and one was identical except for the target item. The subject was asked to point

to the "picture you saw before". Secondly, the subject was asked, "Why did you choose this picture?" If the child erred in picture choice or could not explain why a particular choice was made the example was repeated. This process was repeated for the second practice example. The practice items were not identical to any experimental items. Highlighting or no highlighting of target items at inspection or test for each child was identical to the test condition the child would receive.

After the practice session, the subjects were told they would be shown twelve pictures, one at a time. They were given five seconds to study each picture before the experimenter introduced the next picture. Further verbal interaction was kept to a minimum. No questions regarding the labeling of items in the pictures were answered.

In the recognition task, the subjects were asked to point to the picture in each test pair seen before. For each pair the choice made and response latency timed with a stopwatch were recorded.

Each child was tested individually. The test took approximately eight to ten minutes for each subject, which was the maximum amount of time some of the younger children were able to attend to the task.

Results

Preliminary analysis showed no effects due to sex, presentation order or target item and these variables were omitted in subsequent analysis. Analyses of variance (age by inspection condition by test condition) were carried out on the number of correct choices and on the logarithms of the response latencies. A log transformation was used on the latency data to reduce heterogeneity of variance caused by the fact that some preschoolers had extremely long reaction times. Means for number of

correct choices at each age in each condition are shown in Table 1 and means for response latencies before log transformation in Table 2.

Insert Tables 1 and 2 about here

Analysis of number correct showed significant main effects for age and inspection condition, $F(2,172)=19.5$, $p < .001$ and $F(1,172)=64.9$, $p < .001$, respectively. Overall performance by the 8 year-olds (85% correct) was better than that of the younger children and 6 year-olds (76% correct) performed better than 4 year-olds (64% correct), $t(110)=2.7$, $p < .02$ and $t(142)=4.0$, $p < .02$, respectively. In addition, performance was significantly better if the target item was highlighted at inspection (83% correct) than if not (63% correct).

There was a significant interaction of inspection condition and test condition, $F(2,172)=5.2$, $p < .05$. Newman-Keuls tests showed that the two conditions without highlighting at inspection both produced significantly poorer performance than the two conditions with highlighting at inspection. In addition, performance was better in the both-highlighted condition than if highlighting only occurred at inspection, but no significant difference occurred between the no highlighted inspection-highlighted test and no highlighted inspection-no highlighted test. That is, highlighting at test increased performance significantly only when highlighting also occurred at inspection.

A binomial test of probability was performed separately for each age group and condition to determine whether accuracy was significantly

better than chance. The 4 year-olds in the no highlight inspection-highlight test condition did not perform significantly above chance (p = .119) and in the no highlighting inspection-test their performance was just above chance (p = .048). In all other conditions accuracy was above chance performance.

Observations of frequency tables and variances indicated that performance in several conditions may have approached ceiling levels. In the both-highlighted condition 90% of the 8 year-olds, 55% of the 6 year-olds and 33.3% of the 4 year-olds recognized all twelve pictures correctly. In the highlighted at inspection but not at test condition, 30% of the 8 year-olds, 33.3% of the 6 year-olds and 11% of the 4 year-olds chose correctly for all pictures.

As can be seen in Table 1 the pattern of means for age groups appeared to differ somewhat although no interaction of age and condition was found. The mean number correct for the 4 year-olds appeared to be similar in three conditions but increased if highlighting occurred at both inspection and test. For both the 6 year-olds and 8 year-olds the means appeared to differ depending upon whether highlighting occurred at inspection regardless of test highlighting. For this reason and because of possible ceiling level effects, a Kruskal-Wallis test of interaction was performed comparing the data of the 4- and 6-year-olds (see Bradley, 1968, for a discussion of this procedure). No significant interaction was found ($\chi^2(3)=2.5$), indicating support for the AOV results in which no interaction of age with experimental manipulations was found.

Analysis of logarithms of response latencies indicated significant main effects of inspection condition and test condition, $F(1,172)=31.8$,

$p < .001$ and $F(1,172)=53.8$, $p < .001$, respectively. Performance was faster if the target item had been highlighted at inspection (5.2 versus 7.5 seconds) and faster if target items were highlighted at test (4.8 versus 7.9 seconds). There was also an interaction of age level with test condition, $F(2,172) = 3.9$, $p < .05$. Response latencies were faster for older children when target items were highlighted at test, but did not vary with age when target items were not highlighted.

In summary, for the three age groups tested, highlighting at inspection improved accuracy considerably (20% on the average) as well as significantly reducing response time for all three age groups. After highlighting at inspection, highlighting at test further increased response accuracy (9% on the average) but if items were not highlighted at inspection there was no increase in accuracy for highlighted test items. That these results are not due to failure to understand or follow instructions is suggested by the substantial effect of highlighting at inspection and at test on response time. For test highlighting, the effect on response time increased with age, but even the youngest children benefited. Younger children were significantly less accurate in their responses in all four conditions, and the effects of the conditions did not appear to differ substantially for the different age groups.

Discussion

The data from this experiment show that guiding attention to objects during inspection of pictures facilitates recognition memory for those objects. The highlighting manipulation facilitated memory both in the sense of increasing accuracy and also in the sense of decreasing time to respond during the memory test. These results are similar to

the findings of Bacharach, Carr and Mehner (1976) and Carr, Bacharach and Mehner (1977), who found that advance verbal descriptions of certain objects in pictures increased recognition accuracy for those objects, and to the experiment by Howard and Goldin (1979) with kindergarten children. The effect of the present manipulation did not, however, appear to be different for the different age groups, thus casting doubt on the idea that younger children have trouble with pictorial recognition tasks because they do not exhaustively inspect the picture and do not notice details which may be crucial in the later test.

The results may be compared with those of Tversky and Teiffer (1976) and Meyer (1978). Tversky and Teiffer's instructions to pay careful attention to object detail had no effect on recognition accuracy for five- and eight-year-olds, and only a small effect for twelve-year-olds. In contrast, the highlighting manipulation in the present study had a large impact on all age groups including four-year-olds. The difference would seem likely to be due to the greater difficulty of understanding instructions and implementing and maintaining strategy in the Tversky and Teiffer study. In the present study, children were in effect reminded of the instructions by the presence in each picture of an object outlined in red. In addition, the perceptual salience of the coloring would probably have attracted attention to some extent even in the absence of instructions to attend.

Meyer's manipulation of whether recognition was required only for a large central figure or for the central figure and background detail (full recognition) showed better performance with age for full recognition but equally good performance at all ages for central-figure

recognition. Meyer interpreted this as support for a "centration hypothesis": young children do not decenter attention and scan widely. But it is equally possible that the younger children in Meyer's study did not fully understand the full-recognition instructions, or forgot them during the course of a test in which background details were often the same as those in the original pictures. In addition, half of the children in Meyer's experiment were required to verbally identify what they saw. Meyer does not discuss the nature of these verbalizations but for preschoolers the most likely form of verbalization would seem to be labeling of the central figure, which would take attention away from background detail. In keeping with this interpretation, Meyer reported that preschool subjects who verbalized in the full-recognition condition had significantly lower accuracy than those who remained silent. Thus the centration hypothesis was in fact supported primarily (or perhaps only) for preschoolers for whom the effort and/or the interest of labeling the central figure may have decreased their memory of needing also to attend to background detail. In the present study, there were no such distractions.

The data from this experiment also show that highlighting at test decreases response time, presumably by eliminating the need to systematically search and compare the two test pictures for the crucial difference between them. With age, children appear more able to take advantage of the support available for systematic search, but even the youngest children had significantly faster response times with highlighting and thus appear able to benefit from perceptual support of this kind. If

the target item was highlighted during inspection, highlighting at test increases accuracy as well as decreasing response time. If the item had not been highlighted during inspection, it is possible that highlighting at test was distracting to some extent; the item is not in fact exactly the same and the different appearance may in some cases decrease the feeling of familiarity sufficiently that the subject makes a mistake.

The results on accuracy of highlighting at test did not seem to vary with age. This is surprising in view of the findings of Day and Bissell (1978) and Vurpillot (1968) concerning young children's problems in performing paired visual comparisons. In the present study, four-year-olds who received highlighting at inspection did benefit from highlighting at test but six-year-olds and eight-year-olds benefited as well.

Thus, although the manipulations in the present study seemed to be understood and implemented even by the four-year-olds, and resulted in expected effects on recognition accuracy and response time, we are left without an answer to the question of why visual recognition improves with age during the preschool and elementary school years. Future research into this problem would benefit from considering the implicit assumptions of research done to date, including the present study. Most experimenters have assumed that what changes with age is some strategy or routine, that young children fail to label objects, verbally describe scenes, or pay careful attention to visual detail. Such strategies, clearly an important part of memory development on many tasks, are discussed by Brown (1975) under the heading "knowing how to know." Brown, however, also points out that "knowing", that is, the knowledge base

which one brings to a task, is an important part of memory, an argument substantiated by the results of Chi (1978). In the case of picture memory, many studies have failed to take into account the fact that knowledge about how things co-occur in the real world undoubtedly increases with age, that children may simply be less familiar with the scenes we show them than are adults. Kagan, Klein, Haith, and Morrison (1973) did not find different recognition accuracy for familiar and unfamiliar pictures shown to Guatemalan children, but their study involved whole-object recognition rather than memory for component objects of scenes or of figurative detail. Future investigations should attempt to evaluate the effect of knowledge of scenes on memory for objects either by holding familiarity constant across age groups, or by varying familiarity systematically.

A second consideration for future studies should be the children's motivation to perform experimental tasks. Brown and DeLoache (1978) draw attention to a Russian study by Istomina (1978) showing better free recall in preschoolers asked to play a going-to-the-store game, rather than a decontextualized experimental task. Preschoolers often seem to show excellent recognition abilities in everyday life and in playing games. Perhaps age differences in recognition memory would be substantially reduced if motivational differences across ages were reduced by presenting tasks in a game-like context or a context which simulated a real-world situation.

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Table 1

Number and percentages correct for children

at three ages in four conditions

Highlighting at Inspection	Highlighting at Test	Preschool	Kindergarten	Grade 3
No	No	7.1 (59%)	7.8 (65%)	8.9 (74%)
Yes	No	7.9 (66%)	10.3 (86%)	11.0 (92%)
No	Yes	6.4 (53%)	7.6 (63%)	9.1 (76%)
Yes	Yes	9.6 (80%)	10.8 (90%)	11.9 (99%)

Table 2

Response times in seconds for children at three ages in four conditions

Highlighting at Inspection	Highlighting at Test	Preschool	Kindergarten	Grade 3
No	No	9.9	8.6	9.3
Yes	No	6.8	6.5	6.2
No	Yes	6.6	5.7	4.4
Yes	Yes	4.6	3.8	2.3